Before the
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Replacement of Part 90 by Part 88 to Revise the Private Land Mobile Radio Services and the Policies Governing Them	))))	PR Docket No. 92-235

COMMENTS OF MOTOROLA, INC.

Motorola, Inc. (hereinafter Motorola) submits the following comments in response to the above captioned Notice of Proposed

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Motorola actively supports the Commission's overall goal of maximizing spectrum efficiency, but has serious concerns about a number of the specific aspects of the instant Notice of Proposed Rulemaking. The migration plan and power reductions as proposed in the Notice of Proposed Rulemaking are especially troubling. In addition, Motorola believes the emission masks and frequency stability proposed are much more restrictive than necessary, and would unduly limit a users' choice of products. Finally, Motorola believes interspersing private carriers into the 150-174 MHz band as proposed in the "innovator block" concept is ill advised from both a policy and technical perspective. In these comments, Motorola proposes an alternative migration plan and more palatable approaches for limiting power and defining equipment technical parameters.

The migration plan set forth in the NPRM would abruptly shift the entire course of private land mobile regulation toward very narrow band (VNB) technology, which has yet to be proven in a real world environment. In fact, this same technology upon which the Commission appears to have based its refarming proposal has been voluntarily allowed in the 150-174 MHz band since 1985, but has been resoundingly rejected by private land mobile users. Further, it is particularly ironic that the Commission has proposed to force users to squeeze down their communications into such minuscule bandwidths when the Administration, Congress, American businesses and practically the entire telecommunications industry all recognize and support a new wireless era where users will need access to greater amounts of information and correspondingly greater bandwidths to stay competitive and cost-effective. In addition, as discussed in Section V, the Commission's plan would increase interference to millions of current users.

Motorola is at the forefront of research and development of many new and spectrally efficient wireless technologies and systems which our customers have chosen voluntarily, without a government requirement to do so. For example, ASTRO digital systems integrating voice and data on the same 12.5 kHz channel are now being proven in the pubic safety communications environment. We are also developing Motorola Integrated Radio Systems (MIRS), a time division multiple access technique allowing six users to communicate over each 25 kHz channel. FleetCall and other 800 MHz band SMR operators have chosen to implement this technology. Motorola has developed NarrowAMPS Cellular systems, which provide operators and users a three times improvement in channel capacity compared to standard AMPS as an interim step for operators that have not yet decided on US Digital Cellular or code division multiple access (CDMA). Further, Motorola has been chosen by several cellular carriers, including US WEST and Bell Atlantic to supply next generation CDMA systems offering capacity increases approximately ten-fold. In addition, Motorola is a leader in state-of-the-art digital signal processing (DSP) semiconductor products which form the basis for many advances in all phases of communications and computing.

Motorola did not reach its status as a premier American electronics company of over 100,000 employees, however, by merely developing technology in and of itself without regard to customer needs. Customers buy products, not technology, and are more concerned with whether a product matches their requirements for functionality, reliability and cost. Accordingly, choices of technology and associated government regulations must first recognize that the <u>user</u> is the customer to be satisfied.

Motorola has a long history of working together with the wide range of private land mobile users to develop and support a full portfolio of products responsive to their variety of needs. As detailed in these comments, we currently offer 35 families of products and hundreds of different radio models in the 150-174 and 450-512 MHz bands subject to refarming. In addition, Motorola is one of numerous manufacturers working diligently in Project 25 to assist public safety and other users in defining industry-led standards for digital private land mobile systems meeting their operational requirements. In addition to considering users' communications requirements as a basis for this suite of standards, Project 25 recognizes the practicality of implementing new digital systems into the current land mobile environment.

The APCO 25 Spectrum Committee, after considerable analysis, decided that 12.5 kHz digital frequency division multiple access (FDMA) provides the best possible migration to digital technology and its associated benefits. Further, it maintains backward compatibility with current 25 kHz analog technology and interoperability among Public Safety agencies and with Public Service and Federal Government agencies during and after migration. 12.5 kHz digital FDMA, as specified by APCO 25, likewise provides forward compatibility with 6.25 kHz digital FDMA, if and when that technology proves to be the next best choice.

Any successful attempt to refarm the private land mobile bands below 800 MHz must consider the environment which already exists and the practical implementation by the user. These bands currently support over 12 million radios with an imbedded user equipment investment of approximately $25 billion. Products support users' wide variety of coverage areas, features, grades of service, and system cost requirements inherent in the private land mobile services. Users today choose best-fit communication solutions from a wide variety of experienced, competitive suppliers offering entry level <u>portable</u> units in the $200 range with features comparable to radios costing 4 to 5 times that a decade ago. In major urban areas, a given channel is already shared by multiple systems with aggregate mobile loading often

MHz bands, adjacent channel neighbors overlap each other, as channel spacings are narrower than the equipment bandwidth.

In Section VI of these comments Motorola details an alternative migration plan to improve efficiency in the private land mobile bands below 800 MHz.[1] While the details of implementation are described more fully in that section, in general, Motorola recommends the Commission:

- Establish 12.5 kHz as the channel width in both the VHF and UHF bands, allowing users the flexibility to choose routinely whether to employ 12.5 kHz digital or analog equipment or alternatively, two 6.25 kHz subchannels or multiple time slots within their assigned 12.5 kHz channel(s).

- Require through the type-acceptance process that manufacturers begin populating the market with true 12.5 kHz capable equipment, ensuring a smooth migration for users.

- Begin licensing 12.5 kHz channels for all new authorizations issued after January 1, 1996 and provide a 7-10 year amortization/transition period for existing licensees to retire current systems. Users in rural areas where little if any spectrum congestion exists could continue using current equipment on a non-

Project 25 defining standards which industry can use to usher in digital private land mobile systems. In addition, our plan allows the Commission to raise the status of low power operations on a portion of the UHF offset channels and to begin using the remaining offset channels for full power operation. Notably, market trends show an increasing demand for low cost portable-to-portable operation which can be met with 12.5 kHz equipment.

While there are many theoretical claims concerning very narrow band 5 kHz and 6.25 kHz equipment, there is simply too little experience at this stage and users have too much at stake to warrant revamping the entire private land mobile regulatory structure around very narrow band channels.

I. OVERVIEW

Motorola appreciates the opportunity to participate in what is the most significant regulatory proceedings affecting the private land mobile radio services in the past 20 years. By proposing to "refarm" the private land mobile spectrum, the Commission is apparently convinced that without major regulatory changes service quality in the private land mobile services will deteriorate to levels unacceptable to the needs of the user community.

Motorola is not convinced that a major overhaul of these services is necessary at this time. Certainly, draconian measures that impose huge costs on users would not serve the public interest. Nor would regulatory policies that limit the ability of manufacturers to offer a complete line of products intended to serve the wide-varying needs of a diverse user

- How the bands are now being used (e.g. system configurations, interoperability requirements, shared or exclusive use).

The private land mobile spectrum to be refarmed is the most intensely used spectrum regulated by the FCC. There are over 12 million licensed transmitters in the 150-174 MHz and 450-470 MHz bands combined. These two bands contain a total of 24.5 megahertz of assignable spectrum, thus, about 500,000 transmitters are licensed in each one megahertz of spectrum. This is almost 2.5 times the current loading of the cellular spectrum!

Given this incredible utilization of spectrum, the question is not what can be done merely to increase the number of channels in this environment. Rather, the question is what technologies can be offered without major disruption to existing operations. To this end, the ingredients for successful implementation include:

- Increasing spectrum efficiency and access for existing and new users.
- Maintaining or improving the current standards for coverage and grade of service.
- Providing migration paths to new technologies on a channel-by-channel basis in order to maintain inter-operability among users.
- Allowing sufficient time to amortize existing equipment as well as to plan, budget, fund and implement new systems.
- Relying on marketplace forces to choose the most effective new technologies.

- Providing for user-group involvement in developing frequency usage plans for local, regional and national coverage requirements.

As further discussed in these comments, Motorola believes that the best means of satisfying the above criteria in the subject frequency bands is a migration path to 12.5 kHz equipment a major regulatory action that will dramatically impact the private land mobile services. With the appropriate degree of technical flexibility and policy changes, a 12.5 kHz channeling plan will allow manufacturers to offer the following technologies and products:

- 12.5 kHz digital or analog
- 12.5 kHz TDMA.
- Trunking of FDMA or TDMA channels
- 9.6 kbps or higher channel data rates to support fax, file transfer and imaging.
- 6.25 kHz very narrow band equipment as a user option

At the same time, a 12.5 kHz plan with appropriate technical flexibility provides both obvious and possibly less apparent spectrum efficiency improvements, including:

- At VHF, an increase in the frequencies assignable resulting from elimination of adjacent channel geographic spacing requirements.
- At VHF, an increase in assignable frequencies as a result of the transition from 15 to 12.5 kHz spaced channel centers.
- At 450-470 MHz, an increase in the number of primary full power channels resulting from implementation of 12.5 kHz and coordinated repacking of low power offsets.
- At 470-512, doubling of channels resulting from channel splitting.
- In all bands, a 6 to 1 improvement in data throughput for those users who choose to migrate to digital FDMA, as addressed in more detail in Section IV of these comments.
- For those users who establish an exclusive channel assignment through coordination, a significant increase in loading resulting from implementation of centralized trunking as an option.

- Through technical flexibility, the ability to employ multiple subchannels or time slots within a 12.5 kHz channel.

Adoption of a 12.5 kHz channeling plan will not preclude future use of 6.25 kHz equipment. Motorola believes that users should be given the option of migrating to 6.25 kHz equipment if such equipment satisfies their own applications needs without causing interference to existing users. However, it is premature to mandate the use of VNB equipment -- even if the Commission provides a 10 year transition plan. The Commission should first review the performance of VNB in a non-congested RF environment, such as at 220 MHz, before mandating its use in heavily congested environments at 150-174 and 450-512 MHz.

Users need the freedom to make choices based on their own needs, now and in the future. With little operational experience guiding the Commission, mandating VNB technology at this time presupposes some knowledge of those future needs as well as future technological developments. For example, one cannot say for certain whether data transmissions will overtake the demand for voice or that either form of communication can be provided in very narrow bandwidths in a manner that satisfies all users requirements. By adopting a mandatory 6.25 kHz plan today, the Commission may be limiting users' options in the future. Adoption of a 12.5 kHz channeling plan with technical flexibility will allow the "marketplace" to make the correct choice assuming the Commission provides that freedom.

The remainder of these comments will provide the Commission with further information and data to support Motorola's overarching positions.

II. EXISTING ENVIRONMENT AT 150 MHz AND 450 MHz

As noted earlier, the key to successfully implementing a refarming plan is to fully understand the technical nature of the frequency bands under investigation as well as the makeup of the user base relying on those bands. The frequency bands under refarming matters are the 12.5 kHz low power offset assignments between primary channels that are licensed on a secondary basis and restricted to 2 watts transmitter power output.[3]

In the VHF band, frequencies are primarily assigned to Public Safety, Industrial and Land Transportation users with only 14 two-way frequencies assigned exclusively to the Business Radio Service. In contrast, almost half of the frequencies in the UHF band are assigned to the Business Radio Service.[4] All channels below 470 MHz are available on a shared basis by multiple users. Protection is afforded to licensees through the frequency coordination process.[5]

Uses of these frequencies range from simple two or three portable on-site radio systems to total wide area coverage complete with simulcast operations and networks of voting receivers to accommodate portable talkback. Major investments have been made by users to plan and implement these wide area infrastructures and manufacturers have developed a full line of equipment to support these systems. Technological and manufacturing improvements have allowed equipment prices to decline during the past 20 to 30 years such that even the smallest of businesses can now afford two-way communications.

Perhaps the most important characteristic of private land mobile radio is its ability to satisfy the unique internal

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[3] See § 90.267 of the Commission's Rules.

[4] See § 90.75 of the Commission's Rules.

[5] See § 90.175 of the Commission's Rules.

communications requirements of a diverse user community consisting of public safety, public service, transportation, business and industrial organizations. Over the past forty years, manufacturers have tailored their equipment offerings in direct response to user needs and requirements.

For example, Motorola currently offers 35 model families and hundreds of mobile, portable, base station and special application products for the 150-174 MHz and 450-512 MHz bands. Within each model family, scores of different equipment models are available, each unique in their intended band of operation, available power levels and other major options such as secure communications. In Appendix A, Motorola has attached several equipment brochures which provide a complete description of the equipment contained in each model family. The intent here is to familiarize the FCC with the breadth of the industry's investment in the subject frequency bands and to underscore the need for manufacturers to accommodate a multitude of user requirements.

III. ANATOMY OF A SYSTEM CHANGEOUT

When users are required to institute a changeout of their radio equipment, whether it be driven by regulatory action such as the proposed refarming proceeding, technical obsolescence, or the introduction of new value added features, the user must go through a process to accomplish the change. In this regard, it may be useful for the Commission to understand what is required when a user changes his/her system. The process, to varying degrees, will include these steps.

1. Needs Analysis. What must the new system do that the existing system does not? What features and functions will benefit the organization to make it more responsive and efficient? Can there be an increased payback that is measurable?

2. Financial Consideration. What will a new system cost? What are the alternatives, such as upgrading the existing systems? Can the procurement be spread over numerous years to minimize the financial impact? Will it be possible to maintain interoperability with existing equipment during the changeover?

3. Timing of Implementation. Budget Cycle - minimum of one year for small to medium size commercial establishments. Two plus years for government agencies and large commercial or industrial organizations.

4. System Design and Development of Procurement Documents. Again, these are dependent on the size of the agency or business and the complexity of the system. The process

system will operate in a different radio frequency band, this necessarily means replacement of all field units and base stations. On the other hand, if the old frequency(ies) are to be all or part of the new system, then a different set of parameters apply, such as the feature sets supported by the existing field units. Going forward, other complexities will exist as a result of the refarming effort, such as changes in bandwidth, modulation scheme, and access method. In the later case, new field units will have to operate on both the new and old bandwidth and modulation schemes during the migration period to maintain effective communications.

As stated before, some or all of these steps must be considered no matter why the system changeout occurs. Some steps can be undertaken concurrently, but most require a serial approach once

IV. BENEFITS OF DIGITAL

The most significant action to occur in the private land mobile services below 512 MHz will be the introduction and proliferation of digital technology radios. Digital will change the functionality that users expect from land mobile systems and will provide users with significant improvements in the quality of service they receive.

The primary catalyst in the digital conversion is the user community who persistently demand better solutions and enhanced communications to improve the performance of their core business operations. Users realize that effective radio communications creates expanded business opportunities through increased productivity and efficiency. Only through the increased performance capabilities of digital technology will manufacturers be able to satisfy the refined communications demands of the user community.

Sophisticated user groups recognize the promise of digital. APCO's Project-25 committee has been working for almost three years to develop a standard for digital public safety radio systems. Also, the National Communications Systems Agency has a similar effort in place to develop digital standards for Federal Government land mobile users. Together these two groups have been working actively on the definition of an open architecture standard to allow interoperability of digital radios and to provide users with multiple sources in the marketplace. Motorola fully supports efforts to develop digital standards and believes that a common air interface is necessary to realize the benefits of digital technology.

From a technology perspective there are several key developments which have come together to allow us to move into the digital era. The first is the Digital Signal Processor or DSP which has dramatically increased the processing power available to handle digital signals. With the DSP, equipment designers can replace large portions of traditional analog RF radio circuitry with a single microprocessor. In 1984, DSP's could execute about 4 million instructions per second. Today, Motorola is developing technology that can handle 40 million instructions per second.

Naturally, the ability to process so many commands requires increased memory. Fortunately, advances in memory technology have kept pace with the development of digital signal processors for without the ability to store vast quantities of information in a relatively small physical space, manufacturers would be unable to build digital portable radio units that are now playing such an important role in today's marketplace.

The third critical development needed to offer economical digital equipment is the voice coders or vocoders. Over the years there have been several different methods used for digitizing voice. Recent advances in vocoder techniques, such as enhanced linear predictive coding (LPC), allow for digitized voice with good quality in small bandwidths. For example, Motorola's Vector Sum Excited Linear Predictive (VSELP) encoder can recreate voice information with a very high degree of accuracy with only 4.8 kbps of digital information. This is 92 percent less than the original pulse code modulation techniques and easily fits into today's channels.

There are several general types of digital access systems: FDMA, TDMA, and CDMA. FDMA systems split RF channels into smaller channels, each of which can be utilized by independent users. TDMA systems split channels into a series of repeating time slots. Each slot can be utilized by a different user. CDMA systems overlay multiple users on large blocks of spectrum. This method uses very wide bandwidth transmission and heavily coded digital information. Of these access systems, the FDMA and TDMA systems are best suited for private land mobile systems and services.

Motorola is one of the few manufacturers that offers both FDMA and TDMA systems for use in the private land mobile services. Recently, Motorola introduced the ASTRO FDMA system as well as the MIRS TDMA system. Each of these systems addresses different types of user requirements as further discussed below.

The ASTRO Digital system operates in the VHF, UHF, and 800 MHz bands. The ASTRO system design and performance are focused on the enhanced features and capabilities required by private system users. ASTRO provides 12.5 kHz as well as 25 kHz channels. ASTRO is well suited for use in congested frequency bands where shared use of channels and overlapping system interference are realities. Further, ASTRO can be used in both conventional and trunked system configurations.

The MIRS digital system will see its initial deployment in 1993 when it is installed in Fleet Call's Los Angeles ESMR system. MIRS is designed for high density systems, providing at least a six-fold increase in efficiency. In practice, MIRS focuses on maximizing the number of field units and offers dispatch and interconnected telephone-style features.

The impact of digital radio is seen in several key areas: voice quality, signaling and control data capacity, the integration of voice and data, encryption, spectrum efficiency, and facilitating the migration from analog to digital systems. In terms of audio quality, the new generation of vocoders can provide audio quality comparable, or better, to analog voice. This is because, in the analog world, interference added to the radio signal cannot be extracted from the recovered audio. With digital systems, however, error correction protocols can recognize and correct interfering signals in the digital bit stream. Existing protocols now allow usable audio to be recovered even if 10 percent of the original information has been corrupted.

Digital voice quality will remain more consistent throughout the service area as opposed to analog, which tends to degrade with distance. To users in the field, digital voice means good audio quality over a larger portion of the coverage area, fewer missed messages, and fewer repeated messages. This translates to greater efficiency.

Another area where digital systems will have a huge impact on land mobile communications is signaling and control. Today's analog systems allow only limited continuous signaling capacity along with voice messages by utilizing subaudible signaling which can provide at most, 150 bits per second of capacity. Such signaling can effectively provide repeater access and group partitioning.

In the digital world, compressed digital voice and the higher capacity digital modulation methods will allow manufacturers to allow significantly more signaling and control information with the digital voice message. Motorola's existing digital equipment allows up to 2.7 kb/s to be transmitted with voice which is a capacity increase of eighteen times over analog. To the radio user in the field, embedded signaling means more system functionality, higher reliability, and no truncation of voice messages.

In a digital system, immediately after the Push To Talk button is pressed, the radio sends initial signaling. These signals include all information needed to access the system and to provide synchronization. It also includes user information such as source ID's, destination/group ID's, system ID's, repeater access codes, encryption sync and other message type information.

After the initial signaling burst, the radio begins sending frames of digital voice. Embedded between these voice frames is a continuous series of signaling bursts. All of the signaling information is repeated approximately every 1/3 second, to facilitate late entry and fast re-access. To the field user speakers of other radios; in other words, enhanced features with fewer distractions for field personnel.

One of the other advantages that embedded signaling brings to digital systems is an effective method of intermixing voice and data users on the same channel, thereby improving efficiency and operational logistics. With embedded digital signaling, digital radios now provide the equivalent of "busy bits" on both voice and data messages which will remedy the issue of collisions between the dissimilar services.

The new digital modulations and systems optimized for the transmission of digital information will redefine how the land mobile industry views data transmissions. Most of the current analog data systems transmit 4.8 kilobits per second on the 25 kHz channel. Of this, approximately 2.4 kilobits per second is user data and the remainder is error correction coding. In new digital systems we will see user data rates of up to 7.2 kilobits per second, with an additional 2.4 kilobits of error correction information added by the radio to ensure data integrity; all in a 12.5 kHz channel. This represents 3 times as much data throughput transmitted in one half the channel space; or 6 times the efficiency for an equivalent amount of spectrum.

Perhaps the most important aspect of implementing digital technology is the opportunity to move to more spectrum efficient systems with increased functionality for the user. As the Commission looks to more spectral efficient digital technologies, however, it is important to look for technologies that can